# Radiation Symptoms occur because of overexposure to radiation. Most are familiar with the effects of spending too much time in the direct sunlight on a hot summer’s day – the result is a sunburn. Sunburns occur when an individual’s skin is overexposed to the sun and the medical community has gone to great lengths educating people on the harmful effects of the suns radiation. These harmful effects vary from the uncomfortable red, enflamed skin to severe blistering demanding medical treatment. So how does one prevent a sunburn? Spend less TIME in the sun. Cover up your skin with clothes, shade, or sunscreen (SHIELDING). This sounds a lot like the ALARA principle of TIME, DISTANCE and SHIELDING.

We can feel the gentle warmth of the sun’s rays on our body, but the damage being done is slow and the pain is a delayed response to the overexposure of sunlight. Likewise, the ionizing radiation of gamma and x-rays is invisible, it has no smell, but unlike the sun – it cannot be felt at all.

Biological effects of radiation fit into two general categories:

1. **Acute radiation exposure** is when an individual receives a high radiation dose over a relatively short period of time. Acute radiation exposure also called Acute Radiation Syndrome (ARS). ARS results when an individual receives a whole body exposure of 100 to 200 Rems or more (Roentgen Equivalent Man) over a 24-hour time period. The table below shows the likely symptoms associated with differing levels of exposure.
2. **Chronic radiation exposure** occurs over an extended or prolonged time and the results vary depending on the dose of exposure, duration of exposure and individual reaction to the over-exposure.

Roentgens (R), Radiation Absorbed Dose (RAD), Roentgen Equivalent Man (REM), and Quality Factor (QF) are units of radiation measurement and it is important for the radiographer to discern between them each.

**Roentgens (R),** is the unit of measuring radiation exposure in **AIR** for X-rays and gamma rays, which is based on the ionization produced in air. More specifically, the Roentgen is defined as “the radiation flux which will produce 2.083 x 109 ion pairs per cubic centimeter (one electrostatic unit of charge either positive or negative) at a standard temperature and standard pressure (0° C and 760 mm Hg). But for all practical purposes – commit to memory that Roentgens measure ionizing radiation in air.

**Radiation Absorbed Dose (RAD)** is the accepted unit of measurement of absorbed dose in **tissue**. 1 RAD represents 100 ergs of energy imparted per gram of material at the place of exposure.

**Quality Factor (QF)** is a factor or multiplier of the actual biological effects or damage of the specific radiation type on the human tissue. In a sense, not all Roentgens impart equal damage to tissue and therefore we use a QF multiplier to calculate for the Roentgen Equivalent Man (REM). Table 7A below will demonstrate the various QF value of differing ionizing radiation sources.

**Roentgen Equivalent Man (REM)** is defined as the quantity of ionizing radiation of any type which, when absorbed in a biological system, results in the same biological effects as one unit of absorbed dose in the form of low linear energy transfer (LET) radiation. More practically, REM is defined as the product of the RAD multiplied by the QF.

**RAD x QF = REM**

For example, an exposure to 1 R of gamma or X-rays is equal to 1 REM because the QF of gamma and X-rays is 1. However, an exposure to 1R of alpha particles is equal to 20 REM due to the QF of 20 for alpha particles. All things being equal, alpha particles are 20 times worse for human tissue than gamma or x-rays. It is critical for individuals working in nuclear facilities and performing gamma radiography to clearly understand the simple equation above to calculate the REM dose accurately.

The following data is compiled from the NRC and can be seen in an expanded format at the following NRC URL: <https://www.nrc.gov/reading-rm/basic-ref/students/for-educators/09.pdf>

**TABLE 7-A: Quality Factor (QF)**

|  |  |
| --- | --- |
| **Type of Radiation** | **Quality Factor (QF)** |
| X-Rays | 1 |
| Gamma Rays | 1 |
| Beta Particles | 1 |
| Neutron Radiation | 10 |
| High-Energy Protons | 10 |
| Alpha Particles | 20 |

**TABLE 7-B: Biological Effects based on Exposure Rates**

|  |  |
| --- | --- |
| **Dose** | **Summary of Biological Effects** |
| < 5 rad | No immediate observable effects |
| ~ 5 to 50 rad | Slight blood changes may be detected by medical evaluations |
| ~ 50 to 150 rad | Slight blood changes will be noted and symptoms of nausea, fatigue, vomiting, etc. likely |
| ~ 150 to 1,100 rad | Severe blood changes will be noted and symptoms appear immediately. Approximately 2 weeks later, some of those exposed may die. At about 300 - 500 rad, up to one half of the people exposed will die within 60 days without intensive medical attention. Death is due to the destruction of the blood forming organs. Without white blood cells, infection is likely. At the lower end of the dose range, isolation, antibiotics, and transfusions may provide the bone marrow time to generate new blood cells and full recovery is possible. At the upper end of the dose range, a bone marrow transplant may be required to produce new blood cells. |
| ~ 1,100 to 2,000 rad | The probability of death increases to 100% within one to two weeks. The initial symptoms appear immediately. A few days later, things get very bad, very quickly since the gastrointestinal system is destroyed. Once the GI system ceases to function, nothing can be done, and medical care is for comfort only. |
| > 2,000 rad | Death is a certainty. At doses above 5,000 rad, the central nervous system (brain and muscles) can no longer control the body functions, including breathing blood circulation. Everything happens very quickly. Nothing can be done, and medical care is for comfort only |